Climate Observations from the Atmospheric Radiation Measurement (ARM) Program

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The Intergovernmental Panel on Climate Change (IPCC) has reported that ignorance of how clouds might respond to climate change is the greatest impediment to narrowing down uncertainty in climate prediction. To understand the role of clouds, integrated observational strategies involving many collaborating instruments, and long observation times with carefully-maintained calibration, become key to unraveling the intricate atmospheric processes involving clouds, precipitation, water vapor, aerosol, and radiation.

The Atmospheric Radiation Measurement (ARM) Program, funded by the U.S. Department of Energy (DOE), is a pioneering program famed for its innovations in climate observation in general and cloud observation in particular. ARM is a DOE User Facility open to all and has annual calls for proposals. ARM has developed several highly instrumented surface sites and one Mobile Facility for studying cloud formation processes and their influence on radiative transfer, and for measuring other parameters that determine the radiative properties of the atmosphere. It has also developed the capability to support research in other related areas, such as aerosols, carbon flux, sensible and latent heat flux, and hydrology including precipitation and soil moisture.

ARM's surface sites were placed in three climatically distinct regimes: tropical, mid-latitude, and polar. Among them, the Southern Great Plains (SGP) site spanning Kansas and Oklahoma is the largest and most extensive climate research field site in the world. More than 30 instrument clusters have been placed within the SGP site. Key instruments include millimeter wavelength cloud radar; radar wind profilers; micropulse lidars; microwave radiometers; advanced rotating shadowband spectrometer; shortwave and longwave spectrometers; sky imagers; and one of the few operational Raman lidars in the world. Long-term data acquired from this suite of instruments are used to retrieve microphysical and optical properties of aerosols and clouds, to parameterize cloud-radiation interactions in climate models, and to help validate satellite retrievals.

The Mobile Facility, soon to be joined by a second one for marine use, was developed to support short-term (up to a year) experiments in climate regimes different from the fixed sites. It has been successfully deployed at Pt. Reyes National Seashore in California, Niamey in Niger, the Black Forest area in Germany, and Shouxian in China. Measurements from the Mobile Facility have been used for studying the radiative characteristics of marine stratus; the effects of air pollution on cloud microphysical properties and precipitation; the formation and evolution of convective clouds in orographic terrain; the rate at which tropical clouds and dust absorb radiation; and the effects of desert dust and air pollution on the dynamics of the monsoon season.

ARM has also created an Aerial Vehicles Program (AVP) that supports many field campaigns and provides measurements for evaluating and improving remote sensing retrievals and model parameterizations. The AVP provides data that are impossible to get from ground-based instrumentation, for example, ice crystal habit. Field campaigns have included aircraft measurements from the Battelle G-1, the CIRPAS Twin Otter, the NASA ER-2, and a number of privately owned small aircraft. Key instruments measure cloud drop size distribution up through precipitation sizes, cloud scattering phase function, aerosol composition and size and refractive index, cloud ice crystal shape and size, and radiative flux.

The ARM program maintains an excellent operational record of instrument systems, a high quality of data and data products, and aims for ease of user access to data collected from routine ARM measurements, from field campaigns, and from any expanded observational capabilities carried out for users. In this talk, we will show a number of state-of-art operational and research instruments; demonstrate how their measurements improve our ability to predict climate change; show how to access data products and to learn more about ARM's scientific achievements; and highlight future plans and challenges of the ARM program.